ADOT ITS

Introduction

Widespread residential and industrial expansions have become as much a symbol of Arizona as the state's famous Saguaro cactus. People from across the country are flocking to Arizona at a record pace with the state's population growing three times than that of the national average. This growth has placed tremendous demands on the state's transportation system; as result, the Arizona Department of Transportation (ADOT) has been in the midst of the state's largest road construction program ever by expanding rural highways and building a network of freeways in the Phoenix and Tucson metropolitan area.

In addition to adding new miles of highway every year, ADOT has also been investing in technologies to keep traffic moving, to improve response times in emergencies, and provide relevant and timely information to motorists. This technology implementation—called the Intelligent Transportation Systems (ITS)—uses the latest computers, sensors, and communications systems to provide the agency and travelers with the right information at the right time for making better decisions. ITS saves lives: at a time when every second counts, ITS helps detect accidents and notify emergency response teams faster to provide victims with medical attention; ITS saves time: travelers can avoid frustration of getting caught in traffic congestion with providing more accurate traffic information; ITS saves money: new technologies deliver benefits that reduce congestion, improve commercial vehicle operations, and enhance equality of life at a fraction of the cost of building new roads.

The following presents an overview of the ITS activities in Arizona.

URBAN FMS

Background

The Arizona Department of Transportation has been implementing a freeway management system (FMS) for 100 miles of freeway in the Phoenix area. The FMS will equip freeways in the "Valley of the Sun" with state-of-the-art transportation technologies to help reduce congestion, enhance safety, and save fuel.

A Major study of the I-17/I-10 corridor in Phoenix in 1986 recommended a variety of improvements to enable the freeway system in the Phoenix area to operate at reasonable levels of service and safety through the 21st century. Proposed for the I-17/I-10 corridor were freeway widening, frontage road improvements, new and improved interchanges, high-occupancy vehicle (HOV) and transit applications, and a freeway management system (FMS). A study to determine the feasibility of a freeway management system confirmed that such a system was indeed needed, and design subsequently began in 1988. The ADOT FMS implementation in the Phoenix metropolitan area is briefly described below.

Objectives of FMS

- Make optimum use of the freeway system by employing effective freeway management techniques.
- Provide a safe and efficient environment for the freeway users.
- Manage freeway incidents, special events, and abnormal conditions.
- Implement the infrastructure needed for long-term ITS enhancements of freeway system.
- Operate a system that builds and maintains credibility with the motoring public.

- Provide automatic sharing of freeway information with adjacent jurisdictions as well as control of traffic-interchange signals.
- Centralize the management of the freeway system.

Need for FMS

- The major problem on urban freeways is congestion.
- Lost productivity due to congestion costs approximately $100 billion each year in the U.S.
- Traffic accidents—many caused by congestion—drain another $70 billion per year.
- Congestion is characterized by slower-than-desired speeds, increased travel times, increased accident frequencies, and increased operating costs.
- Congestion is caused either by excessive demand in traffic or reduction in roadway capacity.
- Congestion is of two types: a) recurring and b) non-recurring.
- Non-recurring congestion is considered a more serious problem for the operating agency.
- The most common factors contributing to non-recurring congestion are accidents, disabled vehicles, spilled vehicle loads, construction and maintenance activities, presence of emergency vehicles, and vehicles or people on the shoulders.

Benefits of FMS

- Reduces congestion by identifying and determining the nature of incidents so that they can be quickly cleared.
- Saves Lives, saves time, and saves money.
- Improves safety, reduces congestion, enhances mobility, minimizes environmental impact, and saves energy.
- Increases speeds and reduces delays.
- Minimizes or eliminates freeway breakdown conditions during peak periods.
- Maximizes the utilization of physical capacity.
- Increases vehicle throughput.
- Rapid detection and clearing of accidents will reduce congestion and secondary collisions that frequently result and cause additional delays.
- Similar systems in U.S. have reduced accidents by 25 percent.
- Can reduce peak emissions by 10 percent.

Components of FMS

- Detection
- Ramp Metering
- Variable-Message Sign (VMS)
- Traffic-interchange signal (TIS)
- Closed-Circuit Television (CCTV) Monitoring System
- Communications System
- Traffic Operations Center (TOC)

Detection

- Provides volume, speed, and occupancy data.
- Both in-pavement loop detectors and passive-acoustic detectors are used.
- Data is used for incident detection, measurement of effectiveness, and freeway operational capability.
- Consists of double loops in each mainline travel lane at one-third-mile spacing.
- Model-179 controllers are used in the field for detector data processing.

Ramp Metering

- Proven freeway management technique.
- Regulates rate of entering vehicles from on-ramps.
- Spreads out platoons of entering vehicles.
- Increases average freeway speeds and throughput volumes.
- Improves overall safety of operation on freeway and ramp.
- Keeps freeway flow at its optimum.
- No freeway-to-freeway connectors are metered.
- Model-179 controllers are used in the field for ramp metering data processing.

Variable-Message Sign

- Primary technique for providing information to the motorists.
- Capable of quickly changing messages remotely.
- Fiber-optic signs used throughout the state, furnished by a single vendor to facilitate operations and maintenance.
- All signs are alphanumeric, character matrix with 18-inch-high character, and three-line display.
- Signs are generally placed at the following locations: a) at intermediate locations based on volume-to-capacity ratio, accident rate, and diversion potential; b) in advance of freeway-to-

freeway interchanges; c) at entrances to system; and d) at approximately two-mile spacing in urban areas.

- Total-life-cycle cost—based on initial, maintenance, and electrical costs—were used to select the vendor for multi-year procurement contract.

Traffic-Interchange Signal

- Traffic signals at freeway interchanges with crossroads.
- Central traffic signal control system manages signals remotely and alerts the TOC operators of any malfunctions.

Closed-Circuit Television (CCTV) Camera

- Color CCTV cameras with pan, tilt, and zoom capabilities.
- Located on both sides of freeway between interchanges, at approximately one-mile spacing
- Provide continuous freeway monitoring.

Communications Systems

- Provides interconnection between central computer at the TOC and field devices.
- Accommodates data and video.
- Communications trunk lines are placed along both sides of freeway to provide redundancy.
- Twisted-pair and fiber-optic cables are used.
- Communications node buildings are placed in the field to collect information from field devices and transmit the information to the TOC over fiber-optic cables.

Traffic Operations Center (TOC)

- Statewide facility operating 24 hours a day, 365 days a year.
- The 18,000-square-foot building was designed and constructed specifically for the FMS operations, serving as the hub of ADOT's incident management facility.
- The building includes a 2,100-square-foot control room, which serves as the center of activity for the operation of the system.
- Four operator workstations, 32-monitor video display wall, and two large projection screens are installed in the control room, which show the real-time traffic conditions in the Phoenix area and statewide weather and roadway conditions.
- Two large equipment rooms house the communications and computer equipment, and an electronic maintenance area is used for maintenance of the system's electronic equipment.
- Office spaces are provided for the FMS operations staff and contractors.
- Three conference rooms are used for meetings and training sessions, and in the event of a major emergency, the main conference room can be converted into an emergency operations center.

How FMS Works

The two major components of the FMS are **monitoring** (detectors and CCTV cameras) and **control** (ramp metering, VMS, and traffic-interchange signals).

In the Field

- Detectors detect traffic flow patterns and identify congestion.
- Remote CCTV cameras provide visual confirmation of problems.
- Ramp meter controllers regulate access to the freeway.
- Variable-message signs inform motorists of freeway conditions.
- Data and video from field devices are transmitted over twisted-pair and single-mode fiber-optic cables to communications nodes.
- Data and video are multiplexed at the communications nodes and transmitted to the TOC over single-mode fiber-optic cables.

At the TOC

- A UNIX- and PC-based computer system, interconnected with a local-area network, processes the data arriving from the field.
- Video wall of 32 monitors and the large traffic projection screen for the Phoenix freeways provide traffic conditions and incidents.
- The operators use the FMS central system to log and document the observed incidents.

FMS Central Computer System

The central computer system is located at the TOC to monitor and control the vehicle detectors, ramp metering controllers, and provide the capability for the operators to document and organize the observed incidents. The FMS software has been designed, developed, tested, integrated, and documented by consultants to meet the specific needs of the ADOT TOC operations. The central computer system performs the following:

- Monitors all of the equipment for prompt detection of malfunctions and quick dispatch of maintenance personnel.
- Transmit traffic information to the media for dissemination to their listeners and viewers, and advise local signal system operators of freeway conditions, enabling them to implement appropriate responses.
- Provide the interface between the system hardware and the operators and process all of the traffic flow data.

RURAL ITS

Introduction

Most of the ITS efforts have traditionally been directed to address the transportation problems present in urban corridors. The same technologies and functions used in managing the traffic and solving these problems may also be applied in rural settings to improve the safety and operations of the transportation network. In addition, new technologies can be developed specifically for the rural applications directly from the existing functional areas used in urban areas in order to deal with the unique travel characteristics associated with rural travel.

Rural Transportation Characteristics

- Eighty percent of the total highway mileage in the United States is located in rural areas.
- Rural highways have relatively low traffic volumes.
- Rural highways seldom have traffic congestion.
- Many rural travelers have long distances between communities, which demands motorist attention and often causes fatigue.
- Many rural travelers may be unfamiliar with the surroundings.
- Many rural travelers encounter animals, whose presence may create serious hazards.
- Many rural highways have limited sight distances because they are often constructed on existing terrain, including rugged terrain in remote areas.
- It is generally difficult to keep rural highways clear of snow and ice, which can be a serious safety problem.
- Rural highways often receive less maintenance attention than urban freeways.
- Rural highways are multi-jurisdictional, which includes state, county, and other rural roadways.

Rural Travel and Safety

- Most rural communities do not have adequate public transportation systems, such as bus service, transit service, or taxi service.
- While rural highways in the United States carry less than 40 percent of annual vehicle miles traveled, they account for approximately 60 percent of traffic fatalities.
- Work-zone fatalities in non-Interstate roadways are three times higher than those occurring on the Interstate.
- The number of fatal single-vehicle accidents is higher on rural roads than in urban corridors. These accidents include collisions with fixed objects, running off the road, jackknifes, driver dozing, etc. The principal contributing factors include adverse weather, road conditions, and speeding.
- It takes longer to receive emergency medical response in rural areas after an accident has occurred; this is extremely critical when considering the importance of medical care immediately after the crash.

Rural Transportation Needs

The following is a list of major user needs and opportunities for ITS deployment in rural areas. This information also represents the actual investigation and data collection along I-40 corridor in Arizona in 1996.

- Information on weather conditions in high-elevation locations and areas susceptible to severe dust storms, fog, high wind, etc.
- Tourists' needs for traveler information regarding services, attractions, and highway conditions.
- Ability for getting information to and from travelers when they need it.
- Port-of-entry (POE) bypass capability for trucks with proper credentials.
- Railroad-highway grade crossing.

Role of ITS in Rural Environment

The primary roles of ITS in rural environments are in the area of safety and traveler information. ITS technologies—many of which already in use in urban areas—can bring major improvements to the rural settings and create a safer environment for motorists. Some of the ITS applications to be used for rural transportation include the following functional areas:

- Collision avoidance or warning systems.
- Navigation systems with route guidance and traveler information.
- Stranded vehicle (Mayday) signaling.
- CVO technologies (for example, weigh-in-motion, automated bypass).
- Systems that alert drivers when they are about to go off the road.
- Systems that alert drivers to the presence of animals on the roadway.
- Systems that can automatically locate vehicles for both emergency services and public transportation.
- Systems that transmit information to vehicles with on-board communication or by using advanced warning signs.
- Systems for snow and ice detection.
- Systems for monitoring the weather condition.
- Systems to safely stop and inform of runaway commercial vehicles on rural highway grade.

Rural ITS Activities in Arizona

ADOT Transportation Technology Group (TTG) has embarked on the development and deployment of a statewide strategic plan to provide traveler information for rural Arizona motorists. Some of the applications and technologies considered include Advanced Traveler Information Systems (ATIS) through kiosks and 511 telephone system, Road Weather Information System (RWIS), closed-circuit television (CCTV) cameras, and variable-message signs (VMSs).

The strategic plan for early deployment of ITS on I-40 was successfully completed in summer of 1997. This activity included the deployment of Highway Condition Reporting System (HCRS), which provides continuous and up-to-date information on roadway and weather conditions to the users. In addition, TTG has completed the implementation of RWIS and VMS throughout Arizona to provide a safer environment for motorists, as well as the agency's maintenance personnel. A general overview of RWIS and VMS implementation is provided below.

RWIS and VMS Implementation

In northern Arizona, ever-changing weather and roadway conditions warrant reliable systems to warn motorists of the unexpected events and provide timely information. These conditions generally consist of snow, ice, fog, wind, road closures, elk and deer migrations, and rockslides. In eastern Arizona, dust storms have caused major accidents, resulting in loss of lives and property. Dust-alert systems can warn motorists early by providing timely information and guiding them toward safer locations.

Objectives

- Help keep roadways safe in all weather conditions.
- Help protect lives, assets, and property.
- Save time and money.
- Increase efficiency and productivity.
- Dispatch maintenance crews more judiciously.
- Integrate weather information systems into statewide ITS for sharing weather information to handle emergency preparation plan more effectively.

Benefits

- Save money.
- Accelerate response time.
- Reduce unnecessary call-outs.
- Increase efficiency in crew deployment.
- Increase efficiency in material usage.
- Provide timely information.
- Retain mobility.
- Reduce maintenance and operational costs.

Technologies

- <u>Road Weather Information System (RWIS)</u>:
    - ◊ Pavement sensors.
    - ◊ Atmospheric Sensors.
    - ◊ Remote Processing Unit (RPU) for data collection, storage, and transmission.
    - ◊ Central Processing Unit (CPU) for data collection, storage, and presentation.
- <u>Variable Message Sign (VMS)</u>:
    - ◊ Light-emitting fiber-optic technology.
    - ◊ Three-line, 18-character-per-line display.

SUMMARY

The application of ITS technologies is no longer restricted to urban corridors. With increase in rural travel and the statistical data on travel and safety outside of urban centers, providing travel information to motoring public has become of utmost importance. ITS technologies can be used in rural environments to achieve the following objectives:

- Improve safety.
- Provide timely emergency services.

- Disseminate and share information to the travelers.
- Provide efficient flow of traffic.
- Assure enforcement of laws.
- Assure that agencies cooperate efficiently.

In addition, there is a need for an integrated source of roadway information to provide a comprehensive and integrated system for the entire State. ITS has the capability to provide travel information to the public via a range of communications devices and achieve the above objectives.